

Supplement to USDA Aerial Application Manual for Unmanned Aerial Systems - Multicopter



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Forward

This Supplement is intended to provide additional information to supplement the USDA *Aerial Application Manual* for aerial application using multirotor Unmanned Aerial Systems (UAS).

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Introduction

Unmanned aircraft systems (UAS) are defined in the Federal Aviation Administration (FAA) Modernization and Reform Act of 2012 as "an unmanned aircraft and associated elements that are required for the pilot in command to operate safely and efficiently in the national airspace system" (United States House of Representatives, 2012). The International Civil Aviation Organization (ICAO) similarly defines an unmanned aircraft as "an aircraft which is intended to operate with no pilot on board" (International Civil Aviation Organization, 2012). In both cases the UAS is the sum of the aircraft without a human pilot onboard, a ground-based controller, and a link between the two. The UAS may have varying degrees of autonomy ranging from completely controlled by a human operator to fully autonomous with pre-programmed flight paths.

UAS flight crewmembers include the Pilot in Command (PIC), Visual Observer(s) (VO), and Payload Operator(s) (PO). The PIC has final authority and responsibility for the operation and safety of the flight and must be capable of asserting control of the aircraft at all times (Federal Aviation Administration, 2012). The VO(s) primary responsibility is to assist the pilot with collision avoidance (Davis, 2008). PO(s) are responsible for manipulation of the payload equipped to the aircraft (i.e., pesticide applicator, camera, etc.). UAS are otherwise held to the same standard as manned aircraft and must adhere to Title 14 of the Code of Federal Regulations (14 CFR), also known as the Federal Aviation Regulations (Federal Aviation Administration, 2012). On August 29, 2016, 14 CFR Part 107 Small Unmanned Aerial Systems took effect, integrating UAS into the National Aerospace System (Federal Aviation Administration, 2016).

Precision agriculture is expected to be the largest market for UAS (Association for Unmanned Vehicle Systems International, 2013). This market is broken into remote sensing and precision aerial application. Remote sensing is the measurement of properties of an area or object of interest with data acquired from a satellite and aircraft (Schowengerdt, 2006). Precision aerial application is the dispensing of agricultural crop protection materials from an agricultural aircraft optimized by the use of information management tools (Lan, Thomson, Huang, Hoffmann, & Zhang, 2010). In an analysis by the American Farm Bureau Federation (2015), the anticipated return on investment of UAS was as high as \$12 per acre. While the majority of this market is intended for commercial agricultural settings, these technologies may be readily adapted to natural resource management, particularly invasive plant management.

Agricultural aircraft operations are defined in the Code of Federal Regulations (CFR) §137.3 and consist of the use of an "aircraft for the purpose of (1) dispensing any economic poison, (2) dispensing any other substance intended for plant nourishment, soil treatment, propagation of plant life, or pest control, or (3) engaging in dispensing activities directly affecting agriculture, horticulture, or forest preservation" (Federal Aviation Administration, 2016). Pesticide treatment falls under the provisions of dispensing an economic poison.

Personnel Safety

Safety is paramount to a successful aerial application operation. General precautions include:

- Wear protective clothing and equipment appropriate for the pesticide. (The label for each pesticide specifies the protection required.)
- Know the pesticide being applied and how to get emergency help if needed.
- Avoid all unnecessary contact with spray or dust.

Recommendations for specific personnel are listed below.

Pilot in Command & Pilot

If possible, the pilot in command (PIC) and any other pilots should not mix or load highly toxic pesticides. Exposure to toxic pesticides could cause illness that would make it unsafe for the pilot to operate the aircraft. A pilot who has experienced any symptoms of pesticide poisoning should not fly until he has had medical clearance from a physician.

Visual Observer

Visual observers should wear adequate protective clothing appropriate for the chemical being applied. Pilots should not spray or dust over visual observers.

Payload Operator

If a separate payload operator is necessary for the operation, he/she should follow the same safety recommendations as the pilot.

Non-Participants

The application area should be kept clear of all non-participants. In the event of unauthorized entry of a non-participant into the application area, the operation should be terminated immediately.

Preflight Operations

Flight Planning Checklist

1. Perform a Hazard Identification and Mitigation Controls Analysis (Appendix IV)
2. Consult local weather report for the day of the operation, at least 72 hours in advance
3. The PIC must issue a Notice to Airmen (NOTAM) not more than 72 hours in advance, but not less than 48 hours prior to the operation
4. Contact Visual Observers to confirm that they have not consumed any alcoholic beverage 8 hours prior to flight in compliance with Title 14 CFR part 91, § 91.17

Flight Planning Checklist Complete

Preflight Checklist

1. Check NOTAMS for Temporary Flight Restrictions, GPS NOTAM (<https://pilotweb.nas.faa.gov/PilotWeb/>)
2. Verify that local weather is within operating parameters of the sUAS and that the PIC, PO(s) and VO(s) can maintain LOS with the sUAS at all points of the operational area
3. Verify that all operational documents, including flight manuals, are present and accessible to all personnel
4. Conduct a preflight briefing with all personnel to discuss the operational plan (Appendix VI)
5. PIC, PO(s) and VOs should consult the operational manual prior to operation to review relevant responsibilities and procedures as they pertain to the operation plan
6. Designate PIC, PO(s) and VOs locations
7. Designate Launch, Landing, and Non-Normal Landing Zones. Verify that these areas are clear of any obstructions and apply a visual mark.
8. PIC, PO(s) and VOs must visually inspect the operational area to verify that only operational personnel are present
9. Consult aircraft specific checklists (Appendix II and III) for further information on required preflight procedures

Preflight Checklists Complete

Normal Maneuvers

Consult the manufacturers' manuals for the appropriate sUA for specific procedures in addition to those listed below.

Effective Translational Lift

Effective translational lift (ETL) occurs once the rotor system completely outruns the recirculation of old vortices and begins to work in relatively undisturbed air. The flow of air through the rotor system is more horizontal and induced air flow and induced drag are reduced. The angle of attack is effectively increased, which makes the rotor system operate more efficiently. This increased efficiency continues with increased airspeed until the best climb airspeed is reached, and total drag is at its lowest point.

Normal Takeoff

Normal takeoff from the surface is used to move the helicopter from a position on the surface into ETL and a normal climb using a minimum amount of power.

1. Complete run up and adjust controls to center
2. Move throttle forward. Adjust roll and pitch to compensate for UAS movement.
3. Hover Outside of ground effect. Adjust pitch and toll to prevailing winds.
4. Adjust course and climb if necessary.

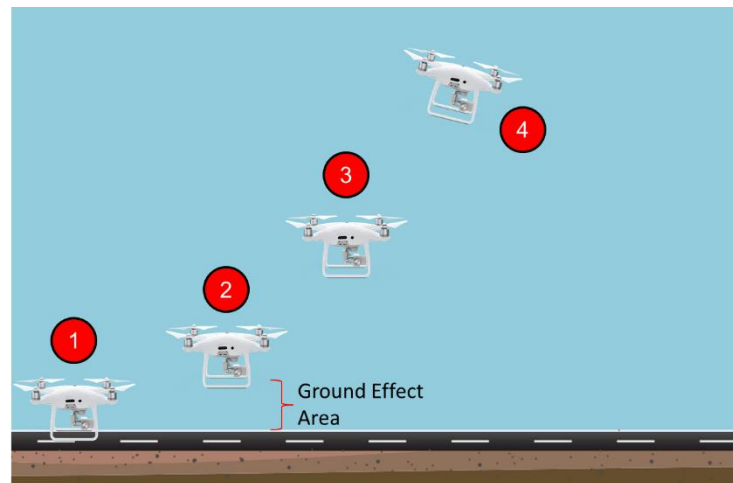


Figure 1. Normal takeoff procedure

Normal Approach and Landing

An approach is the transition from cruising altitude to either a hover or to the surface. The approach should terminate at the hover altitude, or surface, with the rate of descent and groundspeed reaching zero at the same time.

1. Descend at desired rate while maintaining airspeed.
2. Decrease descent rate as the aircraft approaches the landing position.
3. Initiate flare to decelerate.
4. Level off and begin final descent. Adjust controls to center before touchdown if landing.

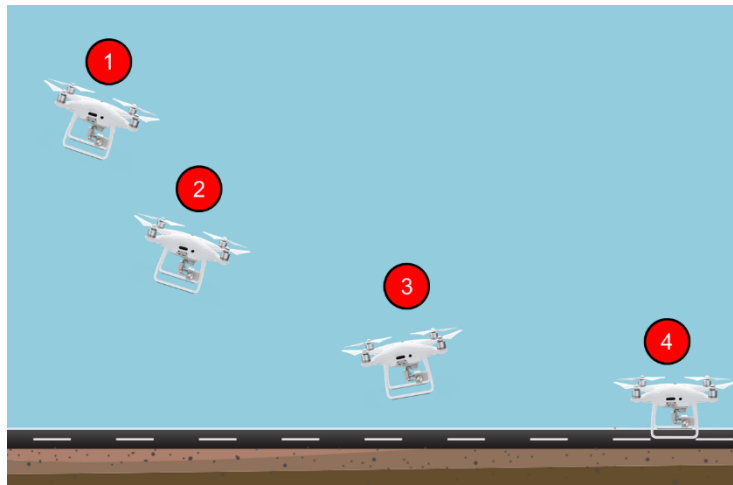


Figure 2. Normal approach procedure.

Steep Approach to Landing

A steep approach is used primarily when there are obstacles in the approach path that are too high to allow a normal approach. A steep approach permits entry into most confined areas and is sometimes used to avoid areas of turbulence around a pinnacle. Caution must be exercised to avoid the parameters for Vortex Ring State (VRS).

1. Descend at desired rate while maintaining airspeed.
2. Maintain high descent rate and airspeed until close to desired landing point.
3. Initiate flare as the aircraft approaches the landing zone.
4. Adjust controls to center just before touchdown.

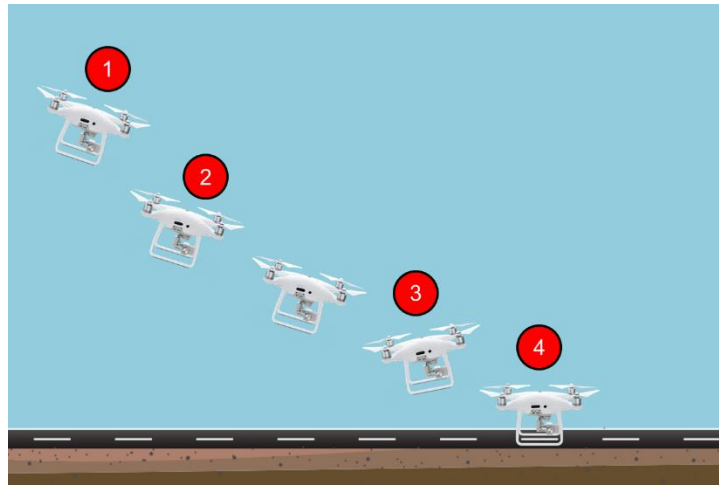


Figure 3. Steep descent to landing procedure.

Go-Around

A go-around is a procedure for remaining airborne after an intended landing is discontinued. A go-around should be performed if the UAS is in a position from which it is not safe to continue the approach. Any time an approach is uncomfortable, incorrect, or potentially dangerous, abandon the approach. The decision to make a go-around should be positive and initiated before a critical situation develops.

1. Make a timely decision to go-around.
2. Apply maximum power, adjust pitch attitude, and allow airspeed to increase.
3. Assume climb attitude.
4. Initiate hover and resume approach.

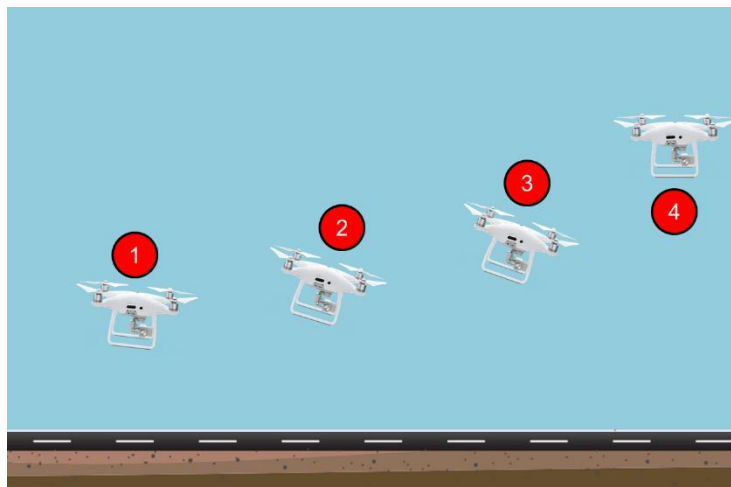


Figure 4. Go-around procedure.

Rapid Deceleration

A rapid deceleration is used to decelerate from forward flight to a hover. It is often used to abort takeoffs or to stop if an obstacle blocks the sUA's flightpath.

1. Accelerate to desired entry speed.
2. Initiate deceleration by applying aft controls. Lower throttle to counteract any climbing tendency.
3. After attaining desired speed reduce aft controls.
4. Descend to normal hovering altitude in level flight and zero airspeed.

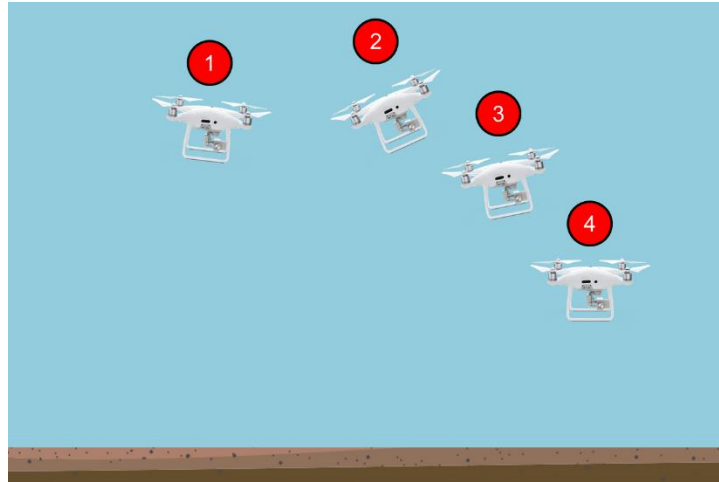


Figure 5. Rapid deceleration procedure.

Slope Operations

Prior to conducting any slope operations, a pilot must be thoroughly familiar with the characteristics of dynamic rollover. Takeoff and landing should be performed across the slope rather than with the slope. Conditions that may be associated with the slope, such as turbulence and obstacles, must be considered during the takeoff. Planning should include suitable forced landing areas.

Takeoff from Slope

1. Complete run up and adjust controls to center. Advance throttle and adjust controls toward the slope.
2. As the skid rise, adjust controls to level attitude. Controls should reach center as the second skid leaves the ground.
3. Once both skids are free of the terrain proceed to a normal hover.

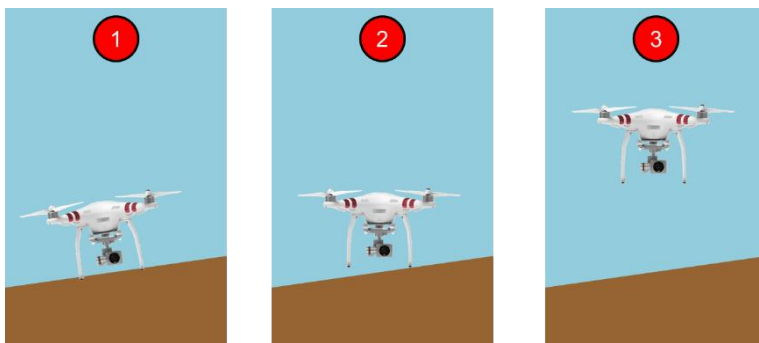


Figure 6. Takeoff from slope procedure.

Landing on Slope

1. Maintain slow descent rate compensating for prevailing winds.
2. As the upslope skid touches the ground, briefly maintain level attitude before adjusting toward the slope. Continue descent adjust to maintain a fixed position.
3. As the downslope skid touches the ground, neutralize controls and steadily decrease throttle until closed.

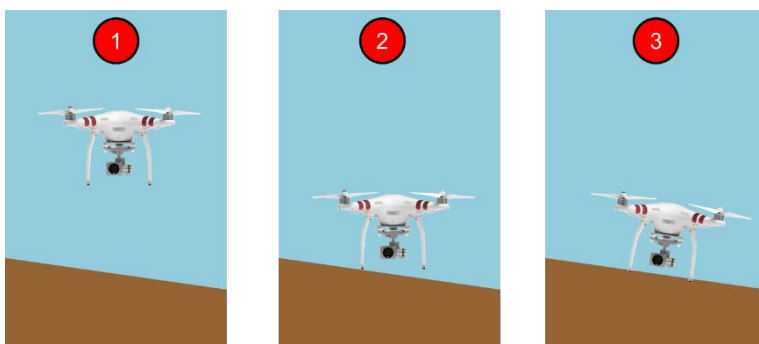


Figure 7. Landing on slope procedure.

Aerial Application Maneuvers

Controlling Drift

Drift is the airborne movement of spray, granule, or dust particles to places other than the target area. Properly controlled drift may help the pesticide reach the target. Drift is harmful when it causes damage in non-target areas. The primary factors leading to drift are droplet size, weather, and vaporization. Below are some additional measures to reduce off-target spray drift.

- Always read and follow the product label directions, including any restrictions. Many labels detail weather conditions, droplet size, equipment and spray drift restraints and/or mandatory no-spray zones to help users manage drift.
- Choose a chemical formulation that is less likely to drift off-target (e.g. use amine formulations of 2,4-D instead of 2,4-D high volatile esters which are more prone to drift as vapor during or after application).
- Check for susceptible plants, animals and areas (e.g. stream, bee hives) close to the target area and put strategies in place to protect them from drift (e.g. use a buffer zone or leave an unsprayed buffer next to a susceptible crop).
- Discuss spray plans with neighboring properties, particularly if there are is sensitive crop or area in the vicinity.
- Ensure equipment is set up and calibrated correctly. Use appropriate checklists
- Use a nozzle or sprayer setting that produces the largest possible droplet size (coarsest spray quality) to reduce the risk of drift without compromising the efficacy of the chemical.
- Before starting operations, check that the weather conditions are suitable for spraying (i.e. wind speeds between 3-15 km/h, blowing away from sensitive crops/areas, temperature below 28°C, no inversion layer present). If the weather is unstable or unpredictable, do not spray. Continue to monitor weather conditions while spraying and stop spraying if conditions become unfavorable.

Swath Run

The swath run (Fig. 10) is the portion of the flight path during which agricultural products are dispensed (A→B and C→D). Maintain constant airspeed, consistent with the calibration of the aircraft, during each pass of an application. Variations in speed during an application may result in uneven coverage. Keep the application height constant during each application pass to maintain the effective swath width that you determined during calibration of the dispersal equipment. Failure to do so will result in difficulty obtaining uniform coverage.

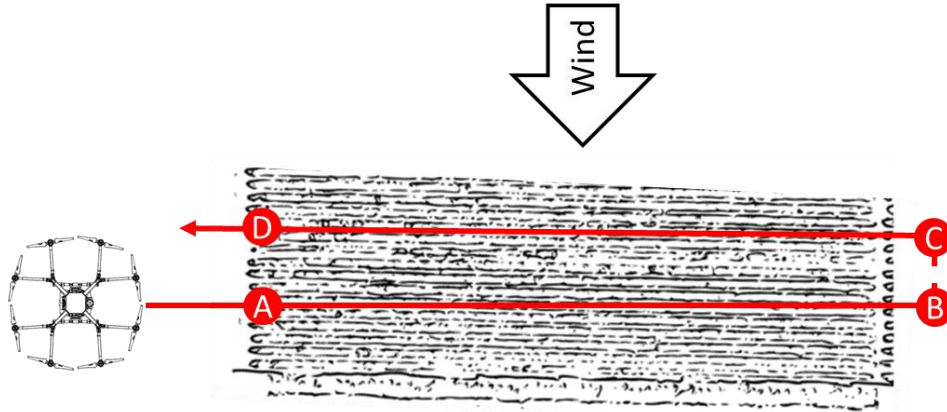


Figure 8. Parallel swath runs perpendicular to wind. First swath run (A→B) is downwind of second run (C→D).

Straight, parallel passes produce the most uniform spray pattern. Whenever possible, passes should be made perpendicular or at a 45° angle to the wind direction to assist in overlap and coverage uniformity. Begin applications on the downwind side of the treatment site to minimize flying through spray suspended in the air from previous swaths. If consistent with wind direction, make application passes parallel to the longest dimension of the treated area to reduce the number of turnarounds.

Spot Spray

An aerial spot-sprayer system is designed to treat individual plants or small areas of target species. The pilot maneuvers the sprayer into position a few feet above the targeted species and releases the pesticide. The ability to maneuver the sprayer into a precise position close to the ground reduces the chance of pesticide drift and of spraying non-targeted species.

Non-Normal and Emergency Maneuvers

UAS Lost Signal, UAS Low Battery, UAS Lost Visual Line of Sight

Software programming on flight controllers which contains a Return to Home (RTH) feature will navigate the UAS to a pilot specified RTH altitude, then transport the UAS to the location of takeoff, unless overridden with a new home location. The RTH feature will trigger automatically in the event of signal loss lasting longer than three seconds or low battery. The RTH feature is triggered manually by the pilot at any time, including in the event of a loss of visual line of sight.

Inclement Weather

The pilot and visual observer(s) should maintain a scan of current weather conditions. In the event of a sudden change in weather the pilot should either initiate the RTH feature or land at the nearest available location.

Flight Over Unwanted Area

Software programming permits creation of geofenced areas that prohibit flight paths over unwanted terrain. The UAS will always be flown within line of sight and the operator should avoid overflight of unwanted areas.

Failure of Mission Planner Software

The pilot must be constantly aware of the aircraft's position and be ready to take manual control if they see any deviations indicating failure of mission planner software. Pilots should immediately alert all crew of any anomalies and if manual control is taken.

Emergency Landing

In the event of an emergency landing, due to the lack of a pilot on board the sUAS, the remote pilot should prioritize the safety of ground personnel and bystanders over the sUA itself.

The different types of emergency landings are defined as follows:

- Forced landing - an immediate landing necessitated by the inability to continue further flight. A typical example of which is a sUA forced down by engine failure.
- Precautionary landing - a premeditated landing when further flight is possible but inadvisable. Examples of conditions that may call for a precautionary landing include deteriorating weather, fuel shortage, and gradually developing engine trouble.
- Ditching - a forced or precautionary landing on water.

A precautionary landing, generally, is less hazardous than a forced landing because the pilot has more time for terrain selection and the planning of the approach.

The overall severity of a deceleration process is governed by speed (groundspeed) and stopping distance. The most critical of these is speed. Dispensable airplane structure and the environment (vegetation, trees, and

manmade structures) may be used as energy absorbing medium in an emergency situation.

UAS Malfunction

A malfunctioning sUA presents a significant hazard to personnel and bystanders. The extent and severity of the malfunction will dictate the response and the PIC should exercise their best judgment in responding to the emergency. The PIC should brief all personnel on the appropriate responses to malfunctions. Recovery of a malfunctioning/damaged sUA should only be performed by trained individuals with appropriate PPE.

If the sUA is still responding to pilot inputs, the remote pilot should land at the nearest location that will pose the smallest hazard to personnel and bystanders. If the sUA is not responding to the remote pilot's controls, flight termination systems should be engaged. If the sUA has an emergency dearming function, this should be used once the sUA is on the ground. If the motors cannot be dearmed and the pilot still has control of the sUA, the remote pilot should exhaust the fuel supply before approaching the sUA.

Flyaway

Flyaways can occur for a variety of reasons, most commonly UAS misconfiguration (e.g., compass), lack of following pre-flight checklist (e.g., setting RTH location), or operator error. The PIC should minimize potential risks by limiting access to the site, posting signage indicating UAS operation, and briefing nearby by non-participants of any risks. The sUA flight termination system is utilized as a last resort to bring down an sUA expeditiously in order to maintain some level of safety to the public or property.

The operating altitude is kept at low to ensure that the sUA will not have sufficient range to fly over a populated area. Similarly, only enough fuel is provided to the sUA to allow successful performance of a flight, but not so much to allow an out-of-control sUA to reach and fly over a populated area.

If a flyaway occurs while operating in airspace that requires authorization, notify ATC as outlined in the authorization.

Tank Puncture or Leak

Only tanks made with puncture resistant materials should be used. The small capacity of UAS tanks reduces the risk created by a complete tank failure as compared to the failure of a large tank on a manned aircraft.

Malfunction of Spraying Equipment (Nozzles, Pumps, Tubing)

All equipment should be tested prior to operation. In the event of a malfunction the pilot should terminate the flight as soon as practical. Visual observer(s) and the payload operator must notify the pilot immediately if they suspect a malfunction.

Vortex Ring State

Vortex ring state describes an aerodynamic condition in which a rotorcraft may be in a vertical descent with 20 percent up to maximum power applied, and little or no climb

performance. Vortex ring state may be caused by descending into the downwash of the aircraft resulting in enlarged tip vortices. In this vortex ring state, most of the power developed by the engines is wasted in circulating the air in a doughnut pattern around the rotor. The result is an unsteady turbulent flow over a large area of the rotor disks. Rotor efficiency is lost even though power is still being supplied from the engines. A fully developed vortex ring state is characterized by an unstable condition in which the aircraft experiences uncommanded oscillations.

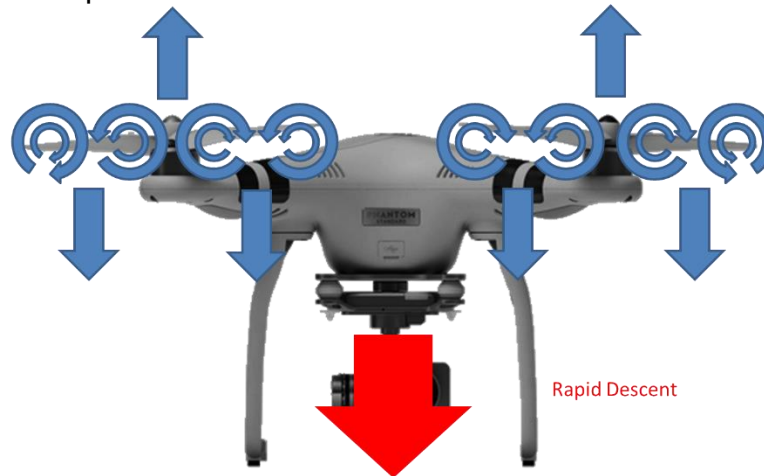


Figure 11. Tip vortices and air currents in vortex ring state condition.

To recover from a vortex ring state condition the pilot should maneuver laterally to exit the disturbed air column and achieve clean air in the rotors.

Crashed sUA Response and Recovery

In the event of a crash, the following checklist may be used:

IMMEDIATELY

- Survey the scene to identify any potential hazards (fire, propellers, shock, etc.).
- Move injured individuals to safe location. Do not enter the wreckage site alone.
- Obtain emergency medical care for the injured.
- Protect property and the environment from further damage.
- Report the accident to the NTSB.
- Preserve the site as intact as possible for investigators.
- Diagram, photograph, and document the accident.
- Identify witnesses.
- Keep bystanders away from the site.

AFTER

- Report the accident to the FAA if necessary.
- Submit Accident/Incident Report (Appendix V).

- Allow an agency performing an investigation (e.g., NTSB or FAA) to recover the sUA if necessary. If cleared to recover the sUA trained personnel with appropriate PPE should initiate the recovery.

RECOVERY

The following PPE are recommended for recovering damaged sUA:

- Fire retardant and laceration resistant outerwear
- Non-synthetic innerwear
- Fire retardant and laceration resistant gloves
- Face shield and safety glasses
- Leather shoes

Recovery Procedure Outline

- If safe to do so, exhaust the available fuel supply prior to approaching the sUA. If the fuel supply cannot be exhausted the connections should be severed to prevent unanticipated powering of sUA systems.
- Once the fuel supply has been exhausted or disconnected the propellers should be removed to prevent further laceration hazard.
- Once the electrical and propulsion systems are properly disabled the sUA may be removed from the site. Exercise caution when handling a crashed sUA.
- Recover any debris as sUA materials may pose an environmental hazard.
- Document the final state of the site following sUA recovery.
- Report sUA recovery to appropriate agency and USDA.

Consult manufacturers' manuals for any additional recommendations and sUA specific procedures.

Fire

A fire extinguisher must be available during UAS flight operations. At the first indication, or suspicion, of smoke, fumes, or a fire within the sUA, all members of the flight crew should be alerted. Fire/smoke warnings and reports of smoke or fumes should be taken seriously until there is POSITIVE confirmation that the warnings are false. The pilot should commence a descent immediately and begin planning for an emergency landing. Contact emergency services as soon as practical. Non-essential crew should be evacuated.

Once the aircraft has landed, follow the procedures detailed in the UAS malfunction section before approaching the sUA. Crew members should not approach the aircraft to extinguish the flames unless they are wearing appropriate PPE, as described in the recovery procedures, and the pilot has cleared them to do so. Exercise caution when approaching the sUA as the fire may propagate through the battery cells as they are exposed to heat. If the fire cannot be extinguished, allow the pack to burn in a controlled and safe way until the fuel source has been exhausted.

Postflight Operations, Maintenance, and Record Keeping

Postflight Check and Securing

1. Turn data collection device(s) off
2. Turn UA off
3. Turn controller off
4. Inspect UA for damage
5. Secure antennas in transport position
6. Transfer operational data, including flight path, to appropriate media storage
7. Complete Post Flight documentation (i.e., flight log)

Maintenance

sUAS maintenance includes scheduled and unscheduled overhaul, repair, inspection, modification, replacement, and system software upgrades of the sUAS and its components necessary for flight. Whenever possible, the operator should maintain the sUAS and its components in accordance with manufacturer's instructions.

Scheduled Maintenance: The sUAS manufacturer may provide documentation for scheduled maintenance of the entire UA and associated system equipment. There may be components of the sUAS that are identified by the manufacturer to undergo scheduled periodic maintenance or replacement based on time-in-service limits (such as flight hours, cycles, and/or the calendar-days). All manufacturer scheduled maintenance instructions should be followed in the interest of achieving the longest and safest service life of the sUAS. If there are no scheduled maintenance instructions provided by the sUAS manufacturer or component manufacturer, the operator should establish a scheduled maintenance protocol.

Unscheduled Maintenance: During the course of a preflight inspection, the remote PIC may discover that an sUAS component is in need of servicing (such as lubrication), repair, modification, overhaul, or replacement outside of the scheduled maintenance period as a result of normal flight operations or resulting from a mishap. In addition, the sUAS manufacturer or component manufacture may require an unscheduled system software update to correct a problem. In the event such a condition is found, the remote PIC should not conduct flight operations until the discrepancy is corrected.

In some instances, the sUAS or component manufacturer may require certain maintenance tasks be performed by the manufacturer or by a person or facility (personnel) specified by the manufacturer. It is highly recommended that the maintenance be performed in accordance with the manufacturer's instructions. However, if the operator decides not to use the manufacturer or personnel recommended by the manufacturer and is unable to perform the required maintenance, the operator should consider the expertise of maintenance personnel familiar with the specific sUAS and its components.

If the operator or other maintenance personnel are unable to repair, modify, or overhaul an sUAS or component back to its safe operational specification, then it is advisable to replace the sUAS or component with one that is in a condition for safe

operation. It is important that all required maintenance be completed before each flight, and preferably in accordance with the manufacturer's instructions or, in lieu of that, within known industry best practices.

Inspection

While the remote PIC is required to perform a preflight inspection, it is advisable to perform a regularly scheduled, detailed inspection of the sUA. A sUAS inspection form may be found in Appendix VII.

Record Keeping

- The operations manager will maintain aerial application records consistent with Appendix I
- Pilots, VOs and POs will record operational hours in a flight log book (i.e., ASA-SP-UAS)
- The PIC shall record aircraft operation hours into an aircraft flight logbook (i.e., ASA-SP-FLT-2)
- The operations manager shall record inspections, tests, repairs, alterations, ADs, service bulletins, and equipment additions, removals or exchanges in an aircraft logbook (i.e., ASA-SA-2)
- The operations manager will maintain remote pilot training records consistent with Appendix VIII and IX

Appendix I. Standard Aerial Application Record

Date	
Contract No.	
Pest	
State	
County	
Contractor Name	
Contractor Mailing Address	
Application Site Contact Name	
Application Site Contact Phone	
Application Site Address	
Pesticide	
Application Rate	
Application Aircraft Make & Model	
Application Aircraft Registration	
Observation Aircraft Make & Model	
Observation Aircraft Registration	

[illegible]

Appendix II. Checklist for Hermes V2

M3 Hermes			V2		
Initial	Pre-Start	Pre-Takeoff	Takeoff	Descent	After Landing
Weather & Den. Alt. Weight & Balance Performance Req. NOTAM - File Air/Heliport - Call Papers - R. O. W. Battery - Installed Control Lock TX - On Master - On Lights Battery Indicator - True Master - Off	Crew Brief Fail Safe/Safety Site Prep Start Autopilot - Off Prop - Clear Master - On Engine(s) - Start	Avionics - On/Set Weather - Check Altimeter - Set GPS - Lock XPDR - Alt + Sqwk ADS-B - On Battery Indicator Flight Controls Instruments H.I. to Compass Engine ESC Time - Note <i>Abort Plan - Ready</i>	Throttle Climb* Landing Gear Autopilot Climb Throttle Battery Indicator Instruments GPS Autopilot Cruise Throttle Battery Indicator Instruments H.I. to Compass GPS Autopilot	Battery Indicator Weather - Check Instruments GPS Autopilot Pre-Landing Throttle Battery Indicator Instruments Autopilot Landing Landing Gear Descent* Throttle Go Around <i>Throttle - Full Positive Rate Climb</i>	Throttle - Lock XPDR - Off ADS-B - Off Securing Master - Off TX - Off Time - Note Control Lock Propellers Close NOTAM <i>*Adjust Speed As Needed For Conditions</i>
Exterior Summary Battery Quantity Battery Quality Engines Propellers Surfaces & Controls Static Ports Landing Gear Antennas Payload Final Walk Around					

Max Climb	500 fpm (0.25 m/s)	Vne • Never Exceed	35 KTAS (65 km/h)
Max Descent	393 fpm (0.2 m/s)	X Wind • Max Demo'd	20 KT (37 km/h)

Make & Model		
Empty Weight:	4.6	KG
Max Payload:	5.0	KG
Max T.O. Weight:	11.5	KG
Battery Type:	6S Li-Po	
Max Flight Time:	22 min	
Electrical:	22.2 V / 22,000 mAh	

Appendix III. Example Hazard Identification and Mitigation Controls Analysis

Hazards:	Pre-Mitigation hazards rate out as:		
	Likelihood A-E	Severity I-IV	Risk Level
1. Mid-air collision with another aircraft	D	II	2
2. Collision with personnel	D	II	2
3. Collision with vehicles	D	IV	1
4. Operating sUA aircraft outside of the approved area	D	III	2
5. Operating sUA outside of manual limitations	E	IV	1
6. Collision with birds	D	III	2
7. Fire During Fueling (Li-Ion battery)	D	II	2
8. Loss of Link with sUA. (LOL)	C	III	2
9. Injury to fingers/hands due to spinning blades on sUA	D	II	2
10. Loss of control	D	III	2
Pre-Mitigation Overall Rating:			Medium
Mitigation Controls:	Post Mitigation hazards rate out as:		
	Likelihood A-E	Severity I-IV	Risk Level
1. The project will be conducted in locations away from any GA airport, Victor airways, or Military Training routes. The operating altitude of less than 400 ft. AGL will ensure adequate separation from any transient general aviation traffic. UAS Operators will practice "See and Avoid."	E	II	2
2. Flight paths will be planned so to avoid people on the ground when approaching for landings. Non-participating personnel will remain clear of the area. Landing areas will be established that minimize risk of impact to people. The project area is remote and public visitation is rare.	E	II	2
3. Vehicles will be parked outside of operating areas.	E	IV	1
4. UA will be programmed to stay within the operating areas in the event of LOL. The operating area is relatively small in size. The sUA will never be operated outside of line-of-sight distances. PIC and VOs are trained and experienced in maintaining control of the sUA.	D	III	2
5. There is no anticipated or expected need to conduct any portion of the survey flight operations outside of manual limitations.	E	IV	1
6. If a bird is encountered and attempting to come in contact with the UA then the pilot shall land as soon as practical in order to prevent injury to the animal and the sUA.	E	III	2
7. A fire extinguisher will be on site and available at all times. Fueling will be done in an area clear of any flammable materials.	D	II	2
8. Prior to launching any sUA the LOL settings will be verified. Loss of Link (LOL) setting will cause the sUA to return to its point of launch and AUTOLAND.	D	III	2
9. Checklist procedures will be followed to ensure that personnel keep their hands clear of rotating blades. Personnel who are not trained or authorized will not be allowed to touch or stand near operating sUA.	D	II	2
10. UAS will not be flown directly above any people, structures, or vehicles, and will only fly within 100' of the operators for purposes of takeoff and landing.	D	III	2
Post-Mitigation Overall Rating:			Medium

Appendix IV. Accident/Incident Report

ACCIDENT ☐ INCIDENT ☐

DATE OF EVENT

____/____/____

LOCATION: CITY/STATE/ZIP

PIC

NAME

DEPARTMENT

DATE OF BIRTH

____/____/____

DATE HIRED

____/____/____

REGULATORY CHECK RIDE

____/____/____

HOURS IN UAS (LAST 90 DAYS) _____

HOURS IN UAS (LAST YEAR) _____

HOURS IN UAS (TOTAL) _____

CERTIFICATION: TYPE/NO.

OTHER PERSONNEL: NAME/ROLE

LOCAL TIME

LATITUDE/LONGITUDE

INJURIES: NAME/ROLE/SEVERITY
(ATTACHED ADDITIONAL SHEETS AS
NECESSARY)

SUAS DAMAGE

NONE ☐ MINOR ☐

SUBSTANTIAL ☐ DESTROYED ☐

UAS REGISTRATION:

N-NUMBER

MAKE

YEAR OF MANUFACTURE

NARRATIVE

(ATTACH ADDITIONAL SHEETS AS
NECESSARY)

Appendix V. Mission Planning/Preflight Briefing Checklist

Review with all participants as part of preflight briefing.

	YES	NO	NA
1. Chain of command, individual roles and responsibilities are identified to all participants?			
2. Is the emergency evacuation plan reviewed?			
3. Are all elements in place to track the UAS at all times?			
4. Can terrain, altitude, temperature or weather that could have an adverse effect be mitigated?			
5. Are all aerial hazards identified and known to all participants?			
6. Have ground operations hazards and safety been identified to all participants?			
7. Have mitigating measures been taken to avoid conflicts with military or civilian aircraft?			
8. Have adequate landing areas been identified and or improved to minimum standards?			
9. Are all personnel qualified for the mission?			
10. Are there enough (qualified) personnel to accomplish the mission safely?			
11. Is the pilot certified and experienced for the mission to be conducted?			
12. Will adequate briefings be conducted prior to flight with all participants?			
13. Is the sUA capable of performing the mission with a margin of safety?			
14. Does the sUA have the capability to perform the mission based on predicted weather conditions?			
15. Is the sUA properly certified?			
16. Do all personnel have the required PPE?			
17. Has required equipment been acquired including maps of areas/sites, handheld radios, cell phones?			
18. Are pilot flight and duty times compromised?			
19. Is there an alternative method that would accomplish the mission more safely?			
20. Have the proper approvals been given by FAA?			
21. If flying in Restricted Airspace, has notification been made with controlling authority prior to launching UAS?			
22. Is a fire extinguisher present?			
23. Other? (identify)			
24. Other? (identify)			
Identify Corrections (if any):			
PIC Signature:		Date:	Observer Signature:
		Date:	

Appendix VI. UAS Inspection Form

UAS Description

UAS Registration Number	
UAS Serial Number	
Airframe Make	
Airframe Model	
Engine Make	
Engine Model	

I certify that this sUA was inspected in accordance with a _____ inspection and was determined to be in an airworthy condition. All work was accomplished in accordance with current Federal Aviation Regulations and Manufacturer's maintenance instructions. Details of work performed are attached.

Inspector Name	
Inspector Signature	
Date of Inspection	
Inspection Valid Until	

ITEM/ACTION	PASS	FAIL	NA
Rotor Group - Head			
Rotor blade grips and blades mounted correctly and secure			
Rotor blade direction correct and blade balance checked			
Rotor blades undamaged			
Blade tracking checked - static			
Control direction correct			
Rotor Group - Tail			
Drive shaft gearing mesh correct			
Drive belt tension correct (if fitted)			
Rotation direction correct			
Tail blade grips and blades secured			
Tail blade direction correct and blade balance checked			
Tail blade pitch range adequate			
Chassis			
Skid set strength			
Skid set secure			
Fasteners locked			
Fuselage			
Mounting to chassis secure			
Braced			
Canopy/Windows secure			
Power Plant			
Fuel tubing secure			

Tank mounting secure			
Clunk and feed connected correctly			
Tank height correct or fuel pump			
Pressure system connected correctly			
Ignition kill switch operation			
Battery size and condition (fouling)			
Wiring and plugs clear, undamaged and secure			
Battery vibration proofed and secure			
Engine, transmission aligned and movement free			
Electric motor speed control condition			
Electric motor power system and wiring condition			
Radio Equipment			
All transmitter functions set up correctly including Fail Safe			
Receiver installation			
Aerial installation			
Switch installation			
Wiring and plugs clear, undamaged and secure			
Control Systems			
Actor link condition			
Servo mounting secure and vibration proofed			
Miscellaneous			
Fasteners locked			
Center of Gravity			
Sense and throw of all control surfaces			
Engine off radio check			
Engine(s) On			
Engine performance and reliability			
Blade tracking			
No airframe vibration			
Radio reliability			
Radio range			
Calibration			
Compass			
Gyroscope			
Accelerometer			
Barometer			
Radar			
Laser			

Appendix VII. Remote Pilot Evaluation

UAS Remote Pilot Evaluation Date:		Evaluation Type: <input type="checkbox"/> Initial <input type="checkbox"/> Recurrent <input type="checkbox"/> Post-Accident	
Pilot's Name (Last, First, Middle Initial, Suffix):		UA Make & Model:	
Department:		Location:	
Knowledge Area	PASS	Knowledge Area	PASS
Preflight Planning		Maneuvers	
(a) Weather		(a) Normal Climb and Descent	
(b) Airspace		(b) Turn to Heading	
(c) sUA Performance		(c) Rectangular Pattern	
Preflight		(d) Turn Around a Point	
(a) Personnel Briefing		Emergency	
(b) Inspection		(a) Low Power, Rapid Descent	
Run-Up		(B) Auto Return to Home	
(a) Calibration		(b) Regain Manual Control	
(b) Instrument Checks		Approach	
(c) Starting and Arming		(a) Normal Approach	
(d) Payload Attachment		(b) Steep Approach	
Takeoff		(c) Go-Around	
(a) Vertical Takeoff to Hover		After Landing and Securing	
(b) Normal Takeoff to Climb		(a) Disarming and Shutdown	
		(b) Inspection Securing	
Pilot Statement: I have been briefed in the reason for this evaluation flight and understand that I will remain as pilot-in-command of the UA during the check and that I may refuse to attempt any maneuver which, in my opinion may be hazardous or unsafe.			
<input type="checkbox"/> Approved <input type="checkbox"/> Disapproved Expiration Date: Remarks:			
Pilot Signature		Evaluator Signature	

Appendix VIII. Unmanned Aerial Applicator Evaluation

Unmanned Aerial Applicator Evaluation Date:		Evaluation Type: <input type="checkbox"/> Initial <input type="checkbox"/> Recurrent <input type="checkbox"/> Post-Accident	
Pilot's Name (Last, First, Middle Initial, Suffix):		UA Make & Model:	
Department:		Location:	
Knowledge Area			PASS
Oral/Written Knowledge Demonstration			
(a) Safe handling of economic poisons and the proper disposal			
(b) Effects of economic poisons and agricultural chemicals			
(c) General effects of economic poisons and agricultural chemicals and precautions for use			
(d) Primary symptoms of poisoning from economic poisons, appropriate emergency measures, and locations of poison control centers			
(e) Safe flight and application procedures			
(f) Performance capabilities and operating limitations			
Skill Demonstration			
(a) Area Survey			
(b) Personnel Briefing			
(c) Inspection			
Run-Up			
(a) Calibration			
(b) Instrument Checks			
(c) Arming			
(d) Payload Attachment			
Maneuvers			
(a) Rapid Deceleration			
(b) Slope Operations			
(c) Swath runs			
After Landing and Securing			
(a) Disarming and Shutdown			
(b) Inspection Securing			
(c) Record keeping			
Pilot Statement: I have been briefed in the reason for this evaluation flight and understand that I will remain as pilot-in-command of the UA during the check and that I may refuse to attempt any maneuver which, in my opinion may be hazardous or unsafe.			
<input type="checkbox"/> Approved <input type="checkbox"/> Disapproved (see Remarks)			
Expiration Date:			
Pilot Signature		Evaluator Signature	